



## **O** Low-Carbon Fuels and Hydrogen

Duke Energy Carolinas, LLC's ("DEC") and Duke Energy Progress, LLC's ("DEP" and, together with DEC, "Duke Energy" or the "Companies") operate Combustion Turbine ("CT") and Combined Cycle ("CC") generation units, which are essential in providing peaking and baseload/intermediate duty service, respectively, and are key for ramping to match load and maintaining a reliable system. These units are generally fueled by natural gas or ultra-low sulfur diesel, which emit CO<sub>2</sub>; however, they can also utilize low- to no-carbon fuels, such as renewable natural gas ("RNG") and hydrogen. The Companies expect new generating units that use low-carbon or hydrogen fuels will become more widely used over time. Additionally, the Companies expect that existing natural gas units will be converted to use low-carbon fuels or hydrogen, which will provide low- to zero-CO<sub>2</sub>-emitting dispatchable generation that supports the resiliency and reliability of the grid.

Low-carbon fuels include biogas and biomass from wood waste, landfills, livestock farm waste, wastewater treatment and other sources of organic materials. In addition, hydrogen, and hydrogen-based fuels, such as ammonia can be low-carbon or zero-carbon fuels. Both low-carbon hydrogen and hydrogen-based fuels are discussed in further detail below.

### **Low-Carbon Fuels**

The Companies are already producing electricity with low-carbon fuels in North Carolina. The current production facilities include:

- Smithfield Foods, Inc., in partnership with Duke Energy and OptimaBio, LLC, is producing RNG from the wastewater treatment system at its Tar Heel, N.C., pork processing facility, which helps power more than 2,000 local homes and businesses and provides approximately 11 megawatts ("MW").
- In Sampson County, N.C., Duke Energy produces 12.8 MW of electricity from landfill gas.
- In New Bern, N.C., Duke Energy converts landfill gas into 4 MW of electricity.
- Duke Energy has a project in rural Buncombe County, N.C., which produces 1 MW of electricity from landfill gas.

Projects such as those listed above were developed to comply with S.L. 2007-397, the 2007 North Carolina Renewable Energy and Energy Efficiency Portfolio Standard however, the Companies are continuing to explore potential low-carbon fuel opportunities. In doing so, the Companies are also working to identify solutions to the current barriers to certain low-carbon fuel markets, including those for the fuel sources listed above. These barriers include limited and inconsistent feedstock production volumes, regulatory uncertainty, quality specifications and cost. As a result, many low-carbon fuel opportunities are in early stages of development and are not cost-effective to implement at the present time. However, hydrogen, which could be a carbon-free fuel, has begun to gain prominence as a viable future fuel.

## Hydrogen

Hydrogen and hydrogen-based fuels are emerging zero- or low-carbon fuels that offer an alternative to fossil fuels. Hydrogen produces heat and energy when burned and emits water vapor as a byproduct. When utilized in an appropriate generating asset, hydrogen can be a zero-emitting load following resource (“ZELFR”), enabling more grid-connected renewable resources. With some modifications to the gas turbines and the development of a robust supply chain, hydrogen could replace, or at least significantly minimize, the use of fossil fuels in industrial processes, the transportation sector, and the generation of electricity.

In addition to hydrogen’s use as a fuel, hydrogen’s value as a long-duration storage technology is also being evaluated by the utility industry. The potential benefits of hydrogen as a storage technology are shown in Figure O-1 below. As more variable renewable resources are added to the grid, the value of long-duration energy storage increases. Given its potential benefits, hydrogen storage could prove to be an important long-duration storage option.

**Figure O-1: Energy Storage Capacity of Hydrogen**

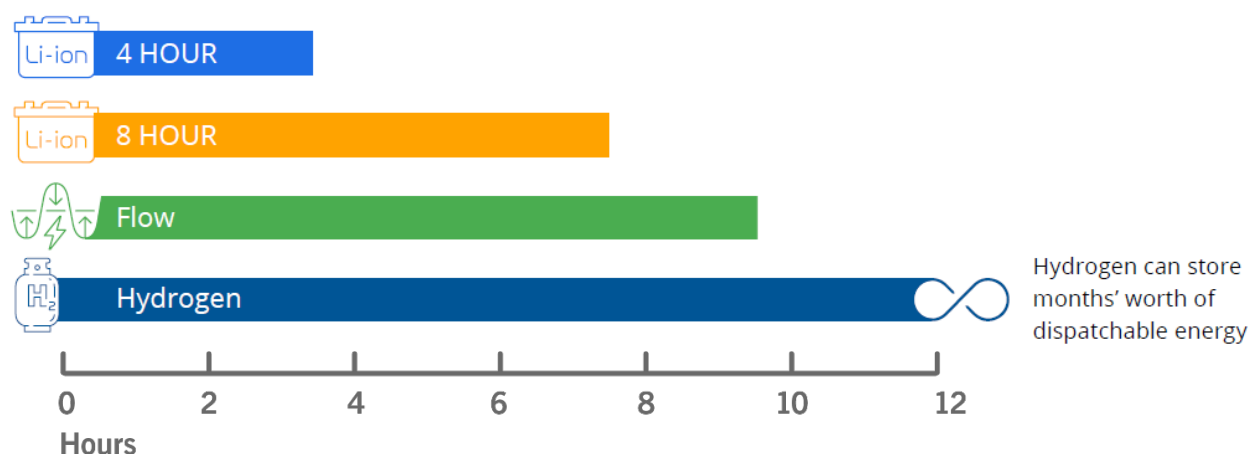


Figure source: Black and Veatch eBook – 2021: Market Dynamics of Hydrogen.

Technology advancements and cost reductions will be required before hydrogen storage can become a viable long-duration storage option. Much of this required technological development is identical to that needed for the broader adoption of hydrogen as a fuel, including improved hydrogen production efficiencies, reduced costs and scaling. In addition, hydrogen storage technologies must be improved including non-geological storage (e.g., compressed hydrogen, liquified hydrogen, metal hydride storage, ammonia storage and others) to improve the viability of large-scale use.

## How Hydrogen is Considered in the Plan

The Companies' generation fleet already includes multiple zero-emitting resources, including solar and nuclear, which can enable the production of hydrogen. As more zero- and low-carbon generation is added to the grid, the ability to produce clean hydrogen should increase. The Companies' generation fleet could also expand the use of hydrogen given that certain existing natural gas generation assets can be partially fueled by hydrogen. If hydrogen technologies and markets continue to develop, then it may become economic to eventually fully convert these units to hydrogen fuel. Additionally, natural gas pipeline infrastructure may eventually be repurposed to support hydrogen fuel.

In Plan modeling, use of clean hydrogen for electric production was limited to support of the longer-term transition to carbon neutrality rather than contributing to the 70% interim target. This is in part due to current limitations and uncertainties around the implementation of hydrogen, including the cost of production, storage costs, production reliability, generation asset technology limits (low emission combustion), limited operational experience with variable resource grids, and transportation limitations as a result of pipeline material and volume limits. The modeling approach assumed that a supply of hydrogen becomes available and can be supplied in two ways: (i) blending into existing pipelines beginning 2035, and (ii) via on-site hydrogen production and storage or dedicated distribution from a hydrogen hub to enable new 100% hydrogen peakers after 2040. Although the timing and cost of these resources continues to develop, for the purpose of the Plan, hydrogen cost was based on the Department of Energy ("DOE") price target for clean hydrogen.

Hydrogen blending is represented with a starting point of approximately 3% in 2035 and ramps up in several steps to approximately 15% in the early 2040s and holding steady thereafter (both numbers representing hydrogen/natural gas volume ratio). This blend is applied to all gas assets existing or added before 2040. Any new peakers built in the 2040s were assumed to be 100% hydrogen fueled, and new combined cycles added to enable coal retirements are converted to 100% hydrogen in the late 2040s.

Progressing into the 2030s and beyond, hydrogen supply and use is expected to significantly grow and become an important component of achieving carbon neutrality by 2050. To assess the potential for adequate hydrogen supply, the Companies reviewed the level of surplus clean energy to see how that could potentially translate into hydrogen volume and back to energy. Confirming the availability of low or zero marginal cost energy is one way to validate potential for the DOE price target that the Companies are assuming. In all Carbon Plan portfolios, the Companies' modeling showed that surplus clean energy (from solar, wind, and nuclear) could provide enough energy to produce all of the blended hydrogen beginning in 2035. The need for hydrogen grows throughout the 2040s as 100% hydrogen

resources are added, but surplus clean energy from the combined system is sufficient to supply approximately half of the total hydrogen needed for 2050 combustion generation assets.

Recent industry studies support the role of gas and gas infrastructure in a decarbonized energy future. Gas for Climate (“GfC”), a group of 10 leading European gas transportation companies and two renewable gas industry associations, recently completed a 2019 study on the most cost-optimal way to fully decarbonize the European Union energy sector by 2050.<sup>1</sup> The study concluded that dispatchable electricity, including gas and hydrogen, is required to meet decarbonization targets and match the substantial growth in wind and solar photovoltaic. In addition, the GfC references the use of gas, through gas infrastructure, offers billions in annual savings across the energy system by 2050.

A follow-up 2020 study showed that the use of dispatchable energy enabled increased opportunities for solar developers to implement intermittent renewables.<sup>2</sup> Hydrogen storage coupled with dispatchable generation could address the intermittency concerns to enable incremental renewables in the future.

## Future Developments and Federal Funding

Considerable federal, state and commercial market action has occurred recently to support the growth of hydrogen in the future energy system. The International Energy Agency (“IEA”) projected global hydrogen demand to increase from 90 million tons (“MT”) to 530 MT in its net-zero by 2050 scenario. To meet that expectation, clean hydrogen production must grow by a factor of 60.<sup>3</sup>

Federal funding and policies have emerged to support hydrogen expansion. In 2020, the DOE announced a planned investment of \$100 million over five years to advance hydrogen research in the U.S.<sup>4</sup> More recently, the Infrastructure Investment and Jobs Act<sup>5</sup> (“IIJA”), signed into law on November 15, 2021, allocated \$8 billion in grants for the establishment of regional hydrogen hubs and \$1 billion in a program to reduce the costs of hydrogen produced from clean electricity.<sup>6</sup>

State and local governments have also adopted policies that promote hydrogen as a decarbonization solution, including the implementation of greenhouse gas emission targets, electricity renewable

<sup>1</sup> Navigant Netherlands B.V., Gas for Climate: The optimal role for gas in a net-zero emissions energy system (Mar. 2019), *available at* <https://gasforclimate2050.eu/wp-content/uploads/2020/03/Navigant-Gas-for-Climate-The-optimal-role-for-gas-in-a-net-zero-emissions-energy-system-March-2019.pdf>.

<sup>2</sup> Guidehouse, Gas Decarbonisation Pathways 2020-2050: Gas for Climate (Apr. 2020), *available at* <https://gasforclimate2050.eu/wp-content/uploads/2020/04/Gas-for-Climate-Gas-Decarbonisation-Pathways-2020-2050.pdf>.

<sup>3</sup> Int’l Energy Agency, Net Zero by 2050: A Roadmap for the Global Energy Sector (Oct. 2021), *available at* [https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b12d840027/NetZeroBy2050-ARoadmapfortheGlobalEnergySector\\_CORR.pdf](https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b12d840027/NetZeroBy2050-ARoadmapfortheGlobalEnergySector_CORR.pdf).

<sup>4</sup> Release, Dept. of Energy, DOE Announces New Lab Consortia to Advance Hydrogen and Fuel Cell R&D (June 23, 2020), *available at* <https://energy.gov/articles/doe-announces-new-lab-consortia-advance-hydrogen-and-fuel-cell-rd>.

<sup>5</sup> Infrastructure Investment and Jobs Act, H.R. 3684, 117th Congress (2021-2022).

<sup>6</sup> *Id.*

portfolio standards and carbon pricing policies. Twenty states have either carbon-free or net neutrality targets within the next 30 years, and many include provisions for hydrogen as a corridor for achieving decarbonization targets.<sup>7</sup> For example, the 2021 Illinois Climate and Equitable Jobs Act required all municipal natural gas-fired units to reach zero emissions by 2045, including using clean hydrogen.<sup>8</sup>

Investments in hydrogen have increased in the commercial market. Globally, there are at least 359 hydrogen projects that represent an estimated \$500 billion in total investments through 2030.<sup>9</sup> The state of Louisiana and Air Products, an industrial gas company specializing in hydrogen, announced in 2021 a \$4.5 billion hydrogen complex to “make the state a leader in the United States clean energy transition.”<sup>10</sup> Notable, publicly announced hydrogen power generation projects include:

- **Intermountain Power Agency:** A 840 MW combined cycle power plant in Utah capable of using a blend of natural gas and 30% hydrogen upon commissioning in 2025. By 2045, 100% hydrogen operation is planned.
- **Long Ridge Energy:** A 485 MW combine cycle power plant in Ohio with current capability to fire a blend of natural gas and 15-20% hydrogen. In the future, the facility has the potential to transition to 100% hydrogen.
- **Okeechobee Clean Energy Center:** A 25 MW electrolyzer will produce hydrogen which will be stored in an on-site storage facility and blended with 95% natural gas as fuel for 1,750 MW CT units in Florida.

The significant federal, state, and commercial activity in hydrogen shows that technology should reach a level of maturity necessary to support Duke Energy in achieving the Plan’s 2050 carbon neutrality target.

## Implementing Hydrogen in the Companies’ Energy System

Advancements in hydrogen technologies and commercial demonstrations are needed to address current hydrogen limitations. Duke Energy is actively engaged with clean hydrogen research, development and demonstration efforts across its industry and service territories.

<sup>7</sup> Clean Energy States Alliance, 100% Clean Energy Collaborative – Table of 100% Clean Energy States., <https://cesa.org/projects/100-clean-energy-collaborative/guide/table-of-100-clean-energy-states/> (last visited May 12, 2022).

<sup>8</sup> Release, State of Illinois, Gov. Pritzker Signs Transformative Legislation Establishing Illinois as a National Leader on Climate Action (Sept. 15, 2021), *available at* <https://illinois.gov/news/press-release.23893.html>.

<sup>9</sup> Release, Hydrogen Council, Hydrogen Investment Pipeline Grows to \$500 Billion in Response to Government Commitments to Deep Decarbonisation (Jul. 15, 2021), *available at* <https://hydrogencouncil.com/en/hydrogen-insights-updates-july2021/>.

<sup>10</sup> Release, Air Products, Louisiana Governor Edwards and Air Products Announce Landmark U.S. \$4.5 Billion Blue Hydrogen Clean Energy Complex in Eastern Louisiana (Oct. 14, 2021), *available at* <https://airproducts.com/news-center/2-21/10/1014-air-products-blue-hydrogen-clean-energy-complex-in-louisiana>.

Duke Energy is an active member of the Southeast Hydrogen Energy Alliance (“SHEA”), a nonprofit partnership that is advancing the commercialization of hydrogen and fuel cell technologies that minimize environmental footprint. Participation in SHEA’s workshops positions Duke Energy to more effectively engage and collaborate with stakeholders. Duke Energy is also a founding member of the Electric Power Research Institute’s and the Gas Technology Low Carbon Resources Initiative (LCRI).<sup>11</sup> The overall target of this initiative is to focus on fundamental advancements in a variety of low-carbon electric generation technologies and low-carbon chemical energy carriers which are needed to enable affordable pathways to economywide decarbonization. Duke Energy also partnered with former DOE Secretary Ernest Moniz’s Energy Futures Initiative (“EFI”) on a case study of a clean hydrogen hub in the Carolinas, which the Companies sponsored as part of a larger EFI study on hydrogen market formation.<sup>12</sup>

Duke Energy’s current hydrogen study and potential hydrogen demonstration in the Carolinas is co-sponsored by Clemson University, Siemens Energy, Duke Energy and DOE. This cross-industry coordination project intends to use hydrogen for energy storage and to produce energy for Duke Energy’s combined heat and power (“CHP”) plant at Clemson University while also leveraging Clemson’s academic research to advance hydrogen technologies. This initiative is also examining the effects of blending hydrogen with natural gas in existing gas turbine applications. Duke Energy regards using hydrogen blended with natural gas as a means to transition to eventual 100% hydrogen usage.

Turbine manufacturers, such as General Electric (“GE”), Mitsubishi and Siemens, have shown success with cofiring hydrogen and natural gas (up to 30% hydrogen by volume) without significant gas turbine revisions in many of the combined cycle and combustion turbine models currently in operation. To progress to 100% hydrogen-fueled turbines, substantial advancements in turbine technology are required. These leading turbine manufacturers have all stated that combustion turbines installed after 2030 will be able to utilize 100% hydrogen. These turbine manufacturers are also developing retrofit technology to allow 100% firing of hydrogen in existing units as well.

Duke Energy continues to seek opportunities to implement hydrogen on its system. A recent opportunity from the DOE issued two Requests for Information (“RFI”) in February 2022 to seek input on the administration of the funds appropriated under the IIJA for hydrogen projects.<sup>13</sup> Duke Energy responded to the RFI and outlined the Companies’ perspective that the Carolinas are uniquely positioned to locate a hydrogen hub, which could provide the foundation for hydrogen to assist in meeting the Companies’ carbon neutrality targets and facilitate emissions reductions in other sectors of the Carolinas’ economy, including heavy-duty transportation.

<sup>11</sup> See Electric Power Research Institute, The Low-Carbon Resources Initiative (LCRI), <https://www.epri.com/lcric> (last visited May 12, 2022).

<sup>12</sup> Energy Futures Initiative, Public Workshop & Private Roundtable Discussion Summary: The Potential for Clean Hydrogen in the Carolinas (Jan. 2022), *available at* <https://static1.squarespace.com/static/58ec123cb3db2bd94e057628/t/61d5af863e99966c9f8fc2d6/1641394064647/Carolinas-PostWorkshopReport.pdf>.

<sup>13</sup> Release, Dept. of Energy, DOE Establishes Bipartisan Infrastructure Law’s \$9.5 Billion Clean Hydrogen Initiatives (Feb. 15, 2022), *available at* <https://energy.gov/articles/doe-establishes-bipartisan-infrastructure-laws-95-billion-clean-hydrogen-initiatives>.



Significant industry investments into research and development as well as operational pilot programs will be required by 2030 and beyond to make clean hydrogen a viable option for 2050 carbon neutrality targets. Operational pilot programs and demonstrations are needed to further advance the technology and commercial feasibility of hydrogen. The current Clemson/Siemens/Duke Energy/DOE-supported studies can be economically expanded to a scalable demonstration phase and serve as a test bed to advance hydrogen production and storage technologies. Similar demonstrations with other technologies and use cases should also be considered. Duke Energy continues to evaluate relevant demonstrations and use cases that leverage available technologies and reflect the current market.

Currently, the most significant limitations to the adoption of hydrogen as a decarbonization solution are the cost of production, storage, transportation and the volume of supply. The DOE has set aggressive targets for the production cost of hydrogen (\$1/kg in one decade).<sup>14</sup> Meeting this target will require a combination of technology costs and performance improvements as well as lower electrical costs. Hydrogen storage and transportation capabilities must be expanded, and the associated costs reduced. Most of the natural gas pipelines today have limited ability to transport hydrogen. Pipelines have been proven to be a cost-effective means to transport fuel and increasing their capability to move hydrogen will be important. The projected potential future demand for hydrogen is magnitudes greater than today's production rates. Production, storage and transportation will all have to be significantly increased in order for hydrogen to be a viable solution.

The Companies maintain a fleet of CT and CC generation units in the Carolinas that will continue to be important in maintaining reliability and resilience of the grid as more intermittent resources are added. To achieve the long-term carbon neutrality target in North Carolina House Bill 951, these resources will continue to be needed, and low- to zero-carbon fuels will be required to further reduce the emissions from the operation of these generation units. Through the next decade, the Companies will be focused on piloting and expanding the use of low- and zero-carbon fuels to explore the technical and economic feasibility of these solutions for decarbonizing both the existing and new generation

## Carolinas Carbon Plan

## Appendix O | Low-Carbon Fuels and Hydrogen

fleet, while collaborating with the industry to advance the transition to low or zero carbon fuels for our existing and new fleet of CTs and CCs.